CHAPTER 1

GEOTECHNICAL INVESTIGATION PROCEDURES

100.00 INTRODUCTION

This chapter presents the investigation procedures of the Arizona Department of Transportation. This chapter sets forth minimum geotechnical requirements/standards to be accomplished and documented in a geotechnical report. Geotechnical Services has prepared "Guidelines for Geotechnical Investigation and Geotechnical Report Presentation", for use on all ADOT related projects. These guidelines are included in this manual as APPENDIX C. They supplement the information herein, and contain more comprehensive requirements for subsurface investigations. All geotechnical investigations started after December 31, 1991 will be expected to follow these guidelines and reports will be reviewed accordingly.

101.00 SOURCES OF INFORMATION FOR OFFICE SURVEY

To be effectively carried out, the field survey should be preceded by a thorough study of the project in the office, which should include the following sources of supporting information.

101.01 LOCATION AND DESIGN SECTIONS

Project maps, profiles, and notes of the survey are available from Location Section. A "typical section" showing a generalized cross section of the roadway prism is distributed by Plans Services. Generally, preliminary construction plans are not available at the time the materials investigation is performed. If there are no preliminary plans available, the location map and profile can be used for planning and conducting the geotechnical investigation. The location map shows the horizontal alignment and the profile shows the vertical alignment of the finished gradeline and the native ground in the vertical plane through the roadway centerline. Plans show the horizontal alignment and the profile on the same sheet. There is more survey information on the location map than there is on the plans; however, preliminary plan profiles contain more information than the original profile. For instance, there may be preliminary earthwork data on the profile of the preliminary construction plans. Strategic location of subgrade soil samples can be recommended in the office through intelligent use of plans, maps, and profiles.

101.02 PHOTOGRAMMETRY AND MAPPING

Materials Section has several types of aerial photographs available on file. There is a complete set of Army Map Service (A.M.S.) photographs with an accompanying index. These photographs were taken in 1954 and range in scale from 1:50000 to 1:60000.

There are photographs that follow the alignment of the existing primary and interstate highways at a scale of 1:24000. The primary highway photographs were taken in 1964 and the interstate in 1975.

Also available are photographs of many of the materials pits that were taken at an average scale of 1:6000. These are being taken on a continuing basis and their primary use would be for pit status, especially ownership boundaries and remaining materials quantities in pits.

Photogrammetry and Mapping Services has photo coverage of many areas of the state. Scales may range from 1:3000 to 1:6000. In the compilation of county maps they are obtaining coverage at a scale of 1:60000 over most of the areas.

Special problem areas may require that aerial photography be taken before the investigation of a project can proceed. This might be the case in extremely mountainous areas.

Photogrammetry and Mapping Services will supply special aerial photography on request. Any special request should be made as far in advance as possible so that the work may be scheduled to coordinate with their other work.

101.03 EARTHWORK COMPUTATIONS (PLANS SERVICES)

If preliminary earthwork computations have been accomplished, a soil profile, cross sections, earthwork data, and a mass diagram will be available from Plans Services. These are invaluable sources of information during the office survey and the field survey.

101.04 MATERIALS INVENTORY

A Materials Inventory of the state has been compiled by the Materials Section. Separate inventories have been prepared for each county. These inventories contain generalized geologic information and geologic maps, the location of materials pits and quarries and the engineering properties of the pit materials

with representative laboratory test data. They also contain land status maps which show the ownership or jurisdictional boundaries within the counties. The Inventory is valuable in locating existing and possible future materials sources and determining land status.

101.05 PREVIOUS PROJECTS

Information on file in Materials Section and Engineering Records Services from prior materials investigations and as-built construction project records can be beneficial. As-built plans are essential for investigation of existing roadways for overlay design.

101.06 U.S. GEOLOGICAL SURVEY

Aerial photography is available from the U.S. Geological Survey. Most of the film available is black and white panchromatic. For some purposes, color films or a false color film, such as infrared have been made and will furnish a larger amount of information. Another film of limited usage is black and white infrared.

U.S.G.S. topographic maps are especially valuable aids for location of Public Land Survey monuments. The Materials Section generally updates its file of these maps every three years. The scale of these maps is either 1:24000 or 1:62500.

Rock formations and soil types can be identified from geologic maps that are published by the U.S.G.S. and the State Geological Survey.

101.07 BUREAU OF MINES

The Arizona Bureau of Mines publishes Arizona geologic maps that are helpful in the location of possible aggregate sources.

101.08 SOIL CONSERVATION SERVICE

The Soil Conservation Service of the United States Department of Agriculture has conducted soil surveys that are portrayed on soil maps. These maps have limited engineering value because of the shallow depth explored.

101.09 ARIZONA LAND DEPARTMENT

Well-drilling logs are now required by the State from drilling contractors. These logs are on file at a number of agencies. The Arizona Land Office and the U.S.G.S. have the most complete records. Reports, papers, and technical publications may be researched to obtain detailed information about an area.

101.10 RIGHT-OF-WAY SECTION

Right of entry is necessary prior to entering and doing any work upon any property. The preliminary office survey should include a check with the Right-of-Way Section to be certain that right of entry has been obtained for materials investigation before any field work is begun.

101.11 LAND USAGE

A check should be made to determine the current and proposed land usage so that materials pits may be properly located and will not interfere with proposed usage or reduce land values.

101.12 ROADSIDE DEVELOPMENT SERVICES

Roadside Development Services provides information pertaining to location of rest areas and prepares plans for their design. This service also may request information from the Materials Section as to sources of water or possible well sites for water supply for rest areas.

101.13 GAME AND FISH DEPARTMENT

The Game and Fish Department provides information pertaining to their proposed use of areas involved in construction, access roads that may be required, and specific requirements on land under their control.

102.00 CENTERLINE INVESTIGATION OF NEW CONSTRUCTION AND RECONSTRUCTION PROJECTS

The investigation of the centerline of a new construction or reconstruction project should include a thorough exploration and sampling of the subgrade, the estimation of shrink or swell factors and compensation for ground compaction, the determination of appropriate cut and fill slopes,

recommendations for cut-widening, investigation of water conditions and supplies, investigation of possible slide conditions, and an estimate of necessary clearing.

To properly record observations and data during the investigation, a working soil profile should be developed and pertinent information recorded on this profile. The base document for the working soil profile should be the final centerline profile provided for ADOT by the Location Section.

On reconstruction projects, the procedure can be simplified as no major reconnaissance is needed and sample locations will generally follow the existing centerline. Test hole excavation is also greatly simplified since most holes will be fairly shallow.

102.01 SUBGRADE EXPLORATION AND SAMPLING

The first phase of the subgrade exploration and sampling should be a reconnaissance trip by the crew supervisor, and as many crewmen as may be necessary, equipped with plans, maps, photographs, and other information that has been provided. This trip should include an on-site review of the entire project to enable the supervisor to familiarize himself with the terrain, the location of the centerline, and to note anything that might help in efficiently organizing and executing the work. Each cut and fill section should be studied, noting any possible problem conditions that may develop (possible slide conditions, saturated soils, etc.). Anticipated soils or geological problems should be discussed with the Geotechnical Investigation Engineer at this time so that drilling or special studies, if required, can be started at this stage.

102.02 SAMPLE LOCATIONS

The supervisor should then proceed with the location of proposed test holes. The location of the holes should be determined by an on-site study of the proposed centerline profile and cross sections. Where the terrain has no appreciable side slope and is generally cut-and-fill the holes should be located on the centerline. One hole should be located at each of the "grade in" and "grade out" points. One hole should be located approximately 100 feet in from each of the "grade in" and "grade out" holes and from 100 to 300 feet apart throughout the balance of the cut as required to produce samples that will reasonably represent the material in the cut.

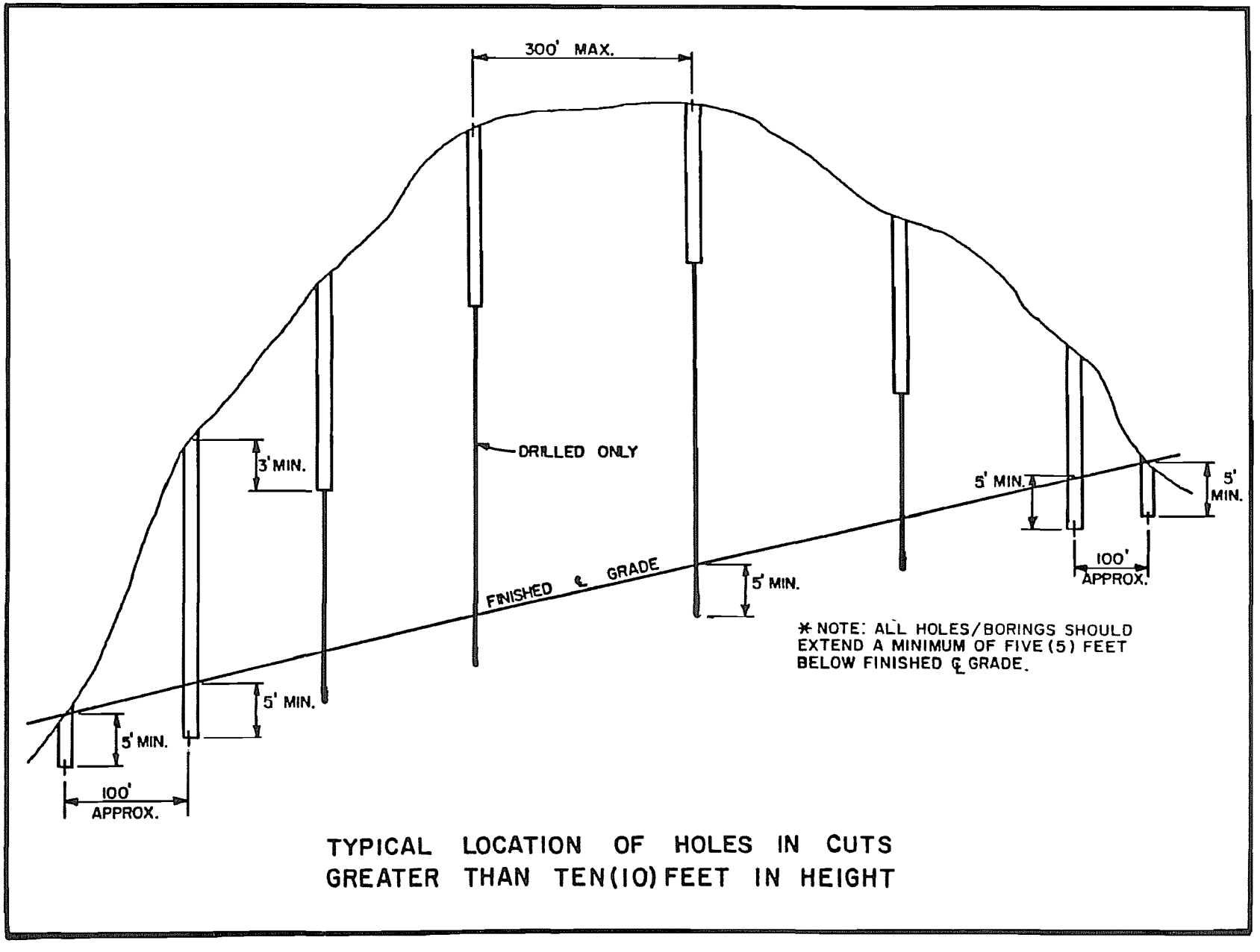
The width of the entire roadway section should be considered when locating subgrade test holes. The profile represents only the relationship of the centerline finished grade with the natural ground line. One or both of the edges of the roadway section may be cutting into a sidehill even though the centerline profile shows a fill section. The crew supervisor should refer to the cross-sections on cuts that involve sidehill excavation, see Figure 102.02-3. Levels should be run to determine the approximate extent of the cut into the sidehill and fill; additional test holes should be located, offset from the centerline, to produce samples that will reasonably represent the material. The distance right or left of centerline, together with the elevation of the top of the test hole, should be recorded on the sample log and on the soil profile. The estimated uniformity of the material would determine the frequency of sampling. (See Figures 102.02-1, 102.02-2 and 102.02-3).

Once the holes are located, they should be marked on the profile and numbered consecutively. A stake should then be placed at each location. This stake should have a metal tag attached identifying the number of the hole, the station, and the depth to which it is to be dug.

The depth of the holes should be determined by the supervisor if they have not previously been designated on the profile sheet. Where it is impracticable to excavate holes to the desired depths, drill holes should be placed to indicate the nature of the material below the excavated depth.

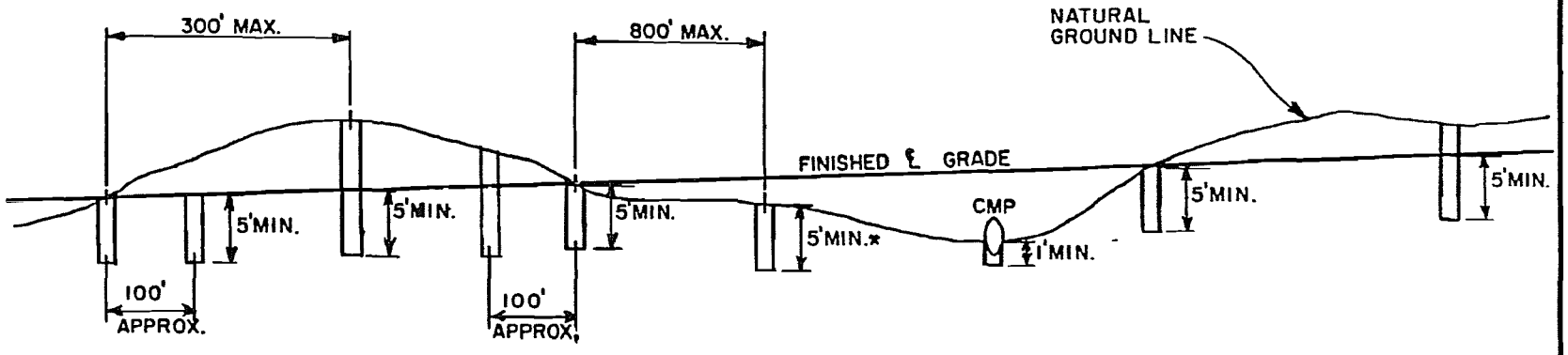
At the "grade out" and "grade in" points, holes should be excavated to a minimum of five feet below finished grade. The remainder of the holes should extend to a depth at least 5 feet below finished grade. On sections where the depth of the cut is quite large, the holes on the lower slopes should extend 5 feet below the finished grade and the other holes should extend at least 3 feet below the top of the adjacent lower hole elevation (see Figure 102.02-1). If the subgrade elevation is out of reach of the usual equipment available to the crew, the Geotechnical Investigation Engineer should be contacted and a decision on whether to use a drill rig will be made.

The crew supervisor should carefully note any evidence of change in the characteristics of the material in each cut section and place the test holes at the proper locations and to the proper depths to reasonably represent all of the various types of material that may be encountered in each cut section. On all embankment sections test holes should be placed, approximately at the point of maximum fill height no more than



TYPICAL LOCATION OF HOLES IN CUTS
GREATER THAN TEN(10) FEET IN HEIGHT

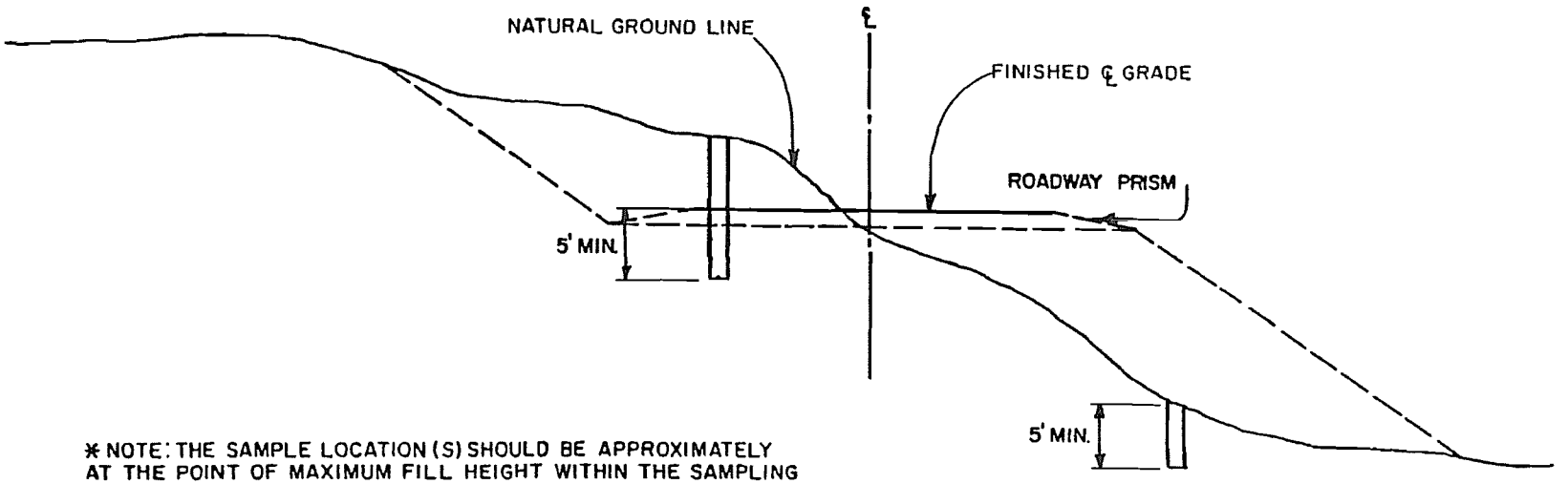
FIGURE 102.02-1



* NOTE: THE SAMPLE LOCATION(S) SHOULD BE APPROXIMATELY AT THE POINT OF MAXIMUM FILL HEIGHT WITHIN THE SAMPLING SECTION(S). IF THE FILL IS GREATER THAN 20 FEET IN DEPTH, THE HOLE/BORING SHOULD EXTEND TO A DEPTH OF THE HEIGHT OF THE FILL OR TO FIRM MATERIAL.

TYPICAL LOCATION OF HOLES IN ALL FILLS AND IN CUTS LESS THAN TEN(10) FEET IN HEIGHT

FIGURE 102.02-2



* NOTE: THE SAMPLE LOCATION (S) SHOULD BE APPROXIMATELY AT THE POINT OF MAXIMUM FILL HEIGHT WITHIN THE SAMPLING SECTION(S). IF THE FILL IS GREATER THAN 20 FEET IN DEPTH, THE HOLE/BORING SHOULD EXTEND TO A DEPTH OF THE HEIGHT OF THE FILL OR TO FIRM MATERIAL.

TYPICAL LOCATION OF OFFSET HOLES

FIGURE 102.02-3

800 feet apart and dug to a depth of at least 5 feet below the ground line or deeper (see Figure 102.02-2 and 102.02-3), so that they may reasonably represent the various types of material that may be underlying each embankment section.

102.03 EXCAVATION

All holes located should be excavated. Excavation may be done by hand shovel or mechanical equipment, whichever may be the most expedient. It may, in some cases, not be practicable to build an access road into a test hole location. Wherever such a situation exists it may be necessary to excavate by hand shovel.

The excavation should be done in a neat manner with the holes no larger than necessary to provide access for observation and sampling. All holes should be backsloped to the proper Occupational Safety and Health Administration standard. In rock excavation where drilling and blasting may be necessary, all blasting should be done in accordance with approved safety requirements. The test holes should be blasted and excavated to a depth that will indicate the nature of the material, and provide access for visual observation and sampling. A drill hole should then be placed in the bottom of the hole and extended to the required depth to confirm uniformity of the material.

Holes which are to be left open for an extended period of time may present a possible hazard and should be fenced or covered in a manner to make then reasonably inaccessible.

The Crew Supervisor should make a visual observation of each hole, make the log of materials and take the samples in accordance with Section 106.00 Sampling Techniques. If the material is stratified, each stratum should be sampled.

102.04 R-VALUE AND SPECIAL SAMPLES

After the test holes have been excavated and the standard samples have been taken as per Section 106.00, the Crew Supervisor should again go over the centerline and, utilizing the open test holes, determine what he considers to be the control condition in each cut or at grade section for R-value sampling and to ensure that each material type has been represented. The Crew Supervisor shall then obtain a 75 to 100 pound R-value sample (depending on rock content) from each site. In some larger cut sections it may be necessary to obtain more than one sample if enough change is noted in the materials

within the cut. The Crew Supervisor and the Geotechnical Investigation Engineer will then review each test hole location and give special attention to the R-value sample locations. If the Geotechnical Investigation Engineer desires different (or additional) samples, he shall so direct. Upon completion of the review, the supervisor will proceed with shipment of the samples to the central laboratory.

The minimum number of R-values required is as follows:

1. Projects, sections of roadway, including intersection improvements, turning bays, bridge approaches, etc., where the total length under construction is less than 1000 feet shall be represented by a minimum of 2 R-value samples. If the materials vary, additional tests may be required.

2. On projects where the total length is between 1000 feet and 5000 feet, a minimum of 3 R-value samples shall be obtained, with at least 2 R-values per major soil type (i.e. 3 major soil types - obtain 6 R-values).

3. On projects where the total length is between 5000 and 16000 feet, a minimum of 4 R-value samples shall be obtained, with at least 2 R-values per major soil type.

4. On projects longer than 16000 feet, a minimum of 2 R-value samples per mile shall be obtained, with at least 2 R-values for each major soil type (i.e. - 5.5 mile project, minimum 11 R-values).

It is stressed that the above are minimal requirements. The responsible engineer should analyze each project to determine actual sample locations and frequency.

One test hole should be placed at each corrugated metal pipe location shown on the plans or profile. If these locations are not shown, the test holes should be placed in any wash or drainage where a pipe might be required. The test hole should be located in the stream bed area and should be staked and marked in the same manner as other test holes. They should be dug to a minimum depth of 3 feet, logged and sampled. If the material in the adjacent drainage channel appears to be of a type that could be abrasive, this should be noted on the working profile. Existing pipe should be visually inspected by the supervisor. Pipe type, coating and condition should be noted on the working soil profile.

The Crew Supervisor should carefully note the type of materials exposed by test holes in the various cut sections, and if it appears that there is a possibility that the excavated materials will be satisfactory for the production of sub-base, base, or surfacing materials, he should report the possibility to the home office. A Geotechnical Investigation Engineer should then visit the site and make a decision regarding the use of the excavated material for base or surfacing materials. If the decision is affirmative, the cut section or sections involved should then be prospected in accordance with the requirements for Materials Pits (Section 104.00).

102.05 EXCAVATION FACTORS AND GROUND COMPACTION FACTORS

As the centerline investigation progresses, the Crew Supervisor should carefully observe each test hole, noting the characteristics of the materials, the amount of overburden, the apparent density of the material in place and make a detailed evaluation of all his observations so that he may estimate excavation factors for the full length of the project. The estimation of excavation factors should be based on experienced judgement, careful observation of the test holes, the ease or difficulty of excavation and by comparison with similar type material from previous projects where the factors have been established. In-place density tests on soil materials will be required, as noted in the following paragraph. The nature of the terrain should also be observed and the possibility of maintaining true lines, grades and slopes should be considered. These factors should then be indicated on the working profile. All stations where there will be excavation should be represented by an excavation factor.

After the estimation of excavation factors, the supervisor should determine the locations for density sampling. It is the intent that this testing be conducted at the same locations selected for classification and soil support determinations. A minimum of 3 locations for each estimated change in excavation factor in soil material shall be tested for an in-place density in accordance with Arizona Test Method 231. If the material within the limits of the estimated factor consists of more than one major soil type, additional tests should be performed to assure that all types are adequately represented. Areas of obvious swell materials will not require in-place density testing.

Each test hole location selected shall be tested at every change in material type. However, if the material within the test hole is the same throughout the full depth, an in-place density shall be performed within each 6-ft. depth. For

example, assuming that the in-place testing will be conducted on a 6 inch depth, a 12 foot cut of one material type will require in-place testing at 2 depths; one plan could consist of conducting tests of 0-6" and 6'-6'6".

At each location where in-place density testing is performed, a sample for laboratory density determination shall be obtained and submitted for testing in accordance with Arizona Test Method 225 or 226.

On projects where the estimated quantity of roadway excavation is 10,000 cubic yards or more, a minimum of 4 locations plus at least 1 additional location for each additional 25,000 c.y. should be tested, regardless of soil uniformity.

The Crew Supervisor should recommend the most likely manner in which the excavation may be accomplished and indicate on the working profile whether it can be dug, ripped or the amount of blasting that may be required during construction.

In addition, an estimate should be made showing the amount of ground compaction (in feet) that should be compensated for. In preparing this estimate, the amount of clearing and grubbing should be taken into consideration because of the loss of material in these operations. The surface of the existing ground should be carefully studied and then the estimate made. Estimated compaction factors should be noted on the working profile covering all embankment stations.

These excavation factors, excavation method and ground compaction estimates should be checked and approved by a Geotechnical Investigation Engineer during the field review. Any changes should be noted on the working profile and initialed and dated by the Geotechnical Investigation Engineer.

102.06 SLOPES

The Crew Supervisor should carefully observe all materials that will be excavated from cut sections and placed in embankment sections and estimate whether the slopes designated in the "ARIZONA DEPARTMENT OF TRANSPORTATION CONSTRUCTION DETAILS" (C-Standards) should be applied to the project. If the nature of the material appears competent and a steeper slope likely may be used, or if it is a material that will not stand on the standard slopes, he should so recommend and note on the working profile. In snow country, consideration should be given for flatter slopes to "daylight" the cut and allow sunlight exposure to the roadway surface. All stations shall have slopes designated.

The estimate of slopes should be checked and approved by a Geotechnical Investigation Engineer during the field review. The Geotechnical Investigation Engineer may determine that testing and further analysis are necessary. Any changes should be noted on the working profile and signed and dated by the Geotechnical Investigation Engineer.

102.07 CUT WIDENING RECOMMENDATIONS

The Crew Supervisor should study the terrain and note on the working profile any area where the cuts should be widened beyond the standard widths. Some conditions that should be considered are: possible snow pack that might damage the subgrade; additional room needed for storage of snow or falling rocks; erosion control requirements; storage of cut slough or slides; etc.

These recommendations should be checked and approved by a Geotechnical Investigation Engineer when he reviews the project with the Crew Supervisor and if there are differences of opinion, they should be discussed on the site and a final decision made. Any changes should be noted on the working profile, signed and dated by the Geotechnical Investigation Engineer.

102.08 INVESTIGATION OF TROUBLESOME SURFACE WATER, SPRINGS, AND SUBSURFACE WATER

The Crew Supervisor should carefully examine the project site and surrounding areas to see if there are any possible stream flows, springs, or underground water that might cause problems during construction or damage to the finished roadway and note such conditions on the working profile. Such conditions should be called to the attention of the Geotechnical Investigation Engineer.

102.09 INVESTIGATION OF POSSIBLE SLIDE CONDITIONS

The crew supervisor should carefully examine all cut sections to ascertain if any incipient slide conditions are indicated and note such locations on the working profile. Such conditions should be called to the attention of the Geotechnical Investigation Engineer, who will further investigate and decide upon the appropriate action.

102.10 CULTURAL AND PALEOTOLOGICAL RESOURCES

Any evidence of Indian ruins, historic sites or fossils on or near the proposed roadway are to be reported to the Geotechnical Investigation Engineer who will transmit the information to the proper authority for investigation. No field work shall be done on such sites without prior clearance.

103.00 INVESTIGATION FOR REHABILITATION OF EXISTING ROADWAY

Instructions in this section are to be used when there are no substantial grade or alignment changes and the project will consist of work on only the existing base and/or surfacing course. It includes such features as overlays, recycling, etc. Where there are substantial grade changes, line changes or substantial widening beyond the existing roadway refer to 102.00.

103.01 SAMPLING EXISTING ROADWAYS

At intervals of approximately 2500 feet (or less as designated by the Geotechnical Investigation Engineer), holes should be placed through the pavement structure, to the top of the subgrade. There should be at least one hole in each pavement typical section and additional holes should be placed in areas that are obviously in a distressed condition. The thickness of the surface course(s) should be measured and recorded and samples taken. Special samples of the existing asphaltic concrete may be required on proposed recycling projects. The Crew Supervisor will be informed when these type samples are needed.

For recycling analysis and design, at least three 6" cores (or equivalent quantity) at each selected sampling location should be obtained. In no case should less than 12 locations in the right wheel path be sampled, uniformly spaced throughout the project, in order to provide enough material for a recycle mix design.

103.02 OBSERVATIONS OF EXISTING ROADWAYS

The investigation should include observations of all conditions that might need consideration in an improvement project. The Crew Supervisor should provide notes concerning the pavement condition where the samples are taken.

A. Pavement Conditions

The pavement should be inspected closely and the condition recorded, with particular emphasis on the nature and extent of cracking, potholing, rutting or any other form of deterioration. A general description of the pavement condition should be written, with notes on the degree of deterioration at specific locations. For example: Milepost 100, cracking - small longitudinal and some transverse cracks up to 1/4"; rutting 1/4" in right wheel path; no pot holes, etc. Milepost 100.5, cracking severe, alligator cracking up to 3/4" with considerable spalling; rutting 1/2" in both wheel tracks; extensive patching, etc.

B. Roadside Conditions

Any roadside conditions that need attention should be noted and recorded. This may include, but is not limited to, the condition of the shoulders, poor drainage areas, erosion problems, etc.

C. Moisture

Any excessive moisture or evidence of previous moisture conditions should be noted and recorded.

D. Other

Any other conditions that might influence the design or construction of the project should be noted and recorded.

104.00 MATERIALS PITS

Available sources of materials to be incorporated in construction projects will sometimes be specified. Locating, prospecting, sampling and testing of these sources and the preparation and presentation of the test data developed should be made available for materials design, estimating and for the contractor's use in bidding.

Before any field work begins, the crew supervisor should study the material provided for him from the office survey, such as maps, aerial photographs, previous projects in the area, etc., to determine in advance what might be the most likely acceptable locations.

The Crew Supervisor, with his crew, should then make a reconnaissance trip and visually check the prospective sources.

There are several factors that result in restrictions on the location of a material pit. The major ones are:

A. A pit should be located no closer than 1500 feet from the roadway unless it is concealed from view and should not be located on the side of a hill visible from the roadway where it will create an unsightly scar, regardless of the distance from the roadway.

B. Wherever possible, pits in waterways should be located upstream from the roadway. If a pit must be located downstream careful consideration should be given to the scouring and erosion possibilities and the pit should be located in such a manner that it will cause the least trouble.

C. Materials sources located in floodplains should not be within one mile upstream and two miles downstream of any highway structure.

D. Materials pits should not be located where the excavation or haul road crosses any utility, either underground or overhead. The utility location should be marked with a 4 inch by 4 inch by 36 inch yellow post, placed 18 inches into the ground.

E. Any evidence of Indian ruins, historic sites or fossils on or near the proposed pit area are to be reported to the Geotechnical Investigation Engineer. No further work shall be done until notification.

104.01 RIGHT-OF-WAY REQUIREMENTS

Right-of-Way for materials sources usually is obtained from one or more of three sources: privately owned land, State owned land or Federally owned land.

A. Privately Owned Land

A Right-of-Way Acquisition Agent may work directly with the field crew and complete the acquisition of the license prior to beginning actual work on the site.

When it appears that suitable material is available, the Crew Supervisor should first attempt to contact the property owner and obtain his permission to enter upon the land. A description of the property sufficient to do a title search can be determined. The legal description of the property, together with the name of the owner when obtainable, should be reported

to the Geotechnical Investigation Engineer. The Crew Supervisor should not proceed with the materials investigation until the license has been obtained or permission to waive this requirement has been granted by the Geotechnical Investigation Engineer.

B. State Owned Land

When it has been determined that the land to be investigated is owned by the State Land Department, the Crew Supervisor should report to the Materials Site Supervisor the legal description of the property he wishes to explore. The Materials Site Supervisor then should prepare a written request for right of entry for investigation purposes and forward it to the State Land Department. When permission has been received, the Crew Supervisor should be notified to proceed.

After the prospecting has been completed, if it is evident that the materials will be usable, a formal request should be made to the Right-of-Way Section for a pit license.

C. Federally Owned Land

If the land to be investigated is Federally owned the same procedure is followed as with State owned land, with the request made to the appropriate federal agency.

104.02 BORROW PITS

Borrow pits are located to provide a source of material to complete the embankment in the roadway.

In addition to the restrictions outlined in Section 104.00, there are several important factors to consider in choosing the location and prospecting a borrow pit.

A. Quality of Material

Although there are usually no specification requirements on borrow, there is definitely a difference in quality of various types of materials. With other factors being relatively equal, the highest quality of material available should be chosen. The quality may be measured by the "R"-value, Plasticity Index, and the percent passing the #200 sieve. Material with low expected "R"-values or highly plastic or fine material should be avoided if other material is available. The plasticity of the material should be checked continually during the prospecting operation, by screening samples through a #40 hand sieve, wetting the portion that passes and rolling it in the hand to estimate the plasticity.

B. Haul Distance

The plans and profile of the proposed project should be studied to estimate where the bulk of the borrow will be used; and the pit should be located in the nearest area where suitable material is available.

C. Prospecting

After the site for the borrow pit has been selected, the backhoe should be moved in and test holes dug. Where the terrain and materials are fairly uniform, holes should be dug in a grid pattern approximately 300 feet apart. If there are obvious changes in the characteristics of the material in various areas of the pit, additional holes should be dug so that each type of material is represented. Sufficient area should be prospected to develop the required amount of material or to delineate the limits of the area of available usable material. If a test hole within the pit area indicates unsuitable material surrounded by satisfactory material, additional holes should be dug to outline the unsuitable area.

Test holes should usually extend to the maximum depth that can be dug safely with the backhoe. All holes should be backsloped in accordance with Occupational Safety and Health Administration requirements. If the material appears to be suitable at additional depths, an occasional selected hole should be extended by bulldozing a hole large enough to provide a working area for the backhoe so that a hole may then be dug in the bottom to indicate additional depth of suitable materials.

If unsuitable material is found at depths less than the capacity of the backhoe, then the holes may be dug only to the bottom of the suitable material. Every test hole should indicate the bottom condition. If applicable, "B.S., N.S." (bottom same, not sampled) should be noted on the log.

Each test hole should be sampled as soon after digging as is practicable. Sampling and logging should be done in accordance with Section 106.00. After all sampling is complete, the samples should be sent to the Central Laboratory.

The "R"-value sampling of the borrow pits shall compare basically with the procedure noted above. First the borrow pit should be laid out, excavated and sampled as required. After the standard samples (P.I., Gradation, Density and pH and Resistivity) have been taken, the Crew Supervisor shall observe the open test holes and determine which holes within the pit area should be sampled for R-values to assure that each material type within the pit has been represented by at least 3 R-value

tests. This should include only the material which is intended to be designated for use and should not consist of clay bottoms or other unsuitable material that would be avoided in actual construction. These R-value samples should be 75 to 100 pounds and retained adjacent to the test hole until the Geotechnical Investigation Engineer reviews the locations and tells the supervisor to proceed with their shipment.

A minimum of 3 locations for each major type of soil material encountered should be selected for density sampling. Each location shall be sampled and tested as noted in Section 102.05, "Excavation Factors and Ground Compaction Factors".

On sources where the estimated quantity of material is greater than 50,000 c.y., a minimum of 4 locations plus at least 1 additional location for each additional 100,000 c.y. should be tested, regardless of soil uniformity.

A metal tape should be prepared on a tapewriter showing the test hole number and the depths of the various strata. For example:

No. 1 - 0/11
No. 2 - 0/4/11
No. 3 - 0/4/6/11

This tape shall be nailed to a wooden stake and placed in the ground near the hole, where it is readily visible and will be preserved. If the pit is in an area that is subject to flooding, the stake should be nailed to a nearby tree, or attached to a post and the post placed in the hole with the tape above ground. Any other suitable method of preserving the tape at the approximate location of the test hole will be satisfactory.

When all pit excavation and sampling has been completed, the Crew Supervisor should call for the pit inspection. The Geotechnical Investigation Engineer should examine each test hole and check the log to verify the accuracy of the depth and description and to be sure that the identifying tape is accurate. If additional samples are required, they should be taken at that time. The Geotechnical Investigation Engineer should also observe the holes within the pit where "R"-values were taken and approve or designate new or additional test locations.

As soon as possible after the inspection, backfilling should begin. Each hole should be filled and the surrounding area left in a neat and relatively smooth condition.

104.03 AGGREGATE PITS

Aggregate pits are located to provide a source of aggregate for the pavement structure of the roadway. In addition to the restrictions outlined in Section 104.00, there are several important factors to consider in choosing the location and prospecting an aggregate pit.

A. Quality of Material

The quality of material in an aggregate pit is of more importance than the proximity to the project as the material must meet more strict requirements than borrow material. For this reason, careful consideration should be given to the selection of aggregate sources, and although the actual quality of the material may not be determined until the material has been sampled and tested, experience and judgement should be exercised in selecting aggregate pit locations.

B. Prospecting

After the site for the aggregate pit has been selected, the backhoe should be moved in and test holes dug. The holes should be on a grid pattern approximately 100 to 250 feet apart. The holes should be to the maximum depth that can be safely dug with the backhoe equipment, or to the bottom of the suitable material, whichever is less. If it is apparent that suitable material extends below the depth to which the backhoe will extend, selected holes in the area should be deepened by bulldozing a hole large enough for the backhoe to operate in and then digging a hole in the bottom. If the depth of the suitable material is greater than the capacity of the equipment, it should be so noted on the pit log. Sufficient area should be prospected to develop the required amount of material or to delineate the limits of the area of the available usable material.

If unsuitable material is found at depths less than the capacity of the backhoe, this should be noted and the bottom marked, as previously indicated. The hole should be deepened into this unsuitable material to attempt to determine its extent, and whether usable material exists below the unsuitable material.

After the holes have been dug, they should be sampled and logged as soon as is practicable. After all sampling is complete, the samples should be sent to the Central Laboratory.

After sampling, each hole should be identified with the metal tape, inspected and backfilled as previously described in Section 104.02.

C. Designation of Aggregate Sources

Test results of the pit samples should be analyzed to determine the quality and characteristics of the material and what it may be used for. The pit should then be designated as a source for one or more of the following: Aggregate Subbase, Aggregate Base, or rejected as a possible source of material, depending on the quality of the material as indicated by the test results.

Frequently, the same pit may be provided for more than one project. When this is the case, the pit should be divided into separate areas, one for each project, in order to provide a work area for each contractor if the projects are constructed simultaneously.

If the pit is in a stream bed or wash that may be subjected to flooding and is to be used for more than one project, the area should be generally allotted from the upstream portion to the earliest scheduled project, and then proceeding downstream for the other projects in the order in which they are scheduled.

104.04 QUARRY INVESTIGATIONS

In the absence of suitable sand and gravel for base and surfacing, a search should be made for a possible quarry source. Quarries will generally be a competent limestone, basalt, quartzsite, or granite formation.

The same restrictions applying to Section 104.02 (borrow pits) and Section 104.03 (aggregate pits) should be observed in locating quarry pits.

A. Quality of Material

Since a quarry pit will be used for aggregate, the quality of the material is of great importance. The cost of investigation of a quarry pit is high compared to that of sand and gravel; therefore, a source should be examined very carefully in the preliminary investigation. Evidence of clay seams, overburden and other deleterious material should be studied. The location of outcroppings of the rock will help to determine the extent of the available, suitable material and will serve to indicate what might be expected in the investigation.

B. Prospecting

After the site for the quarry has been determined, the equipment should be moved in and the test borings made. One or

more borings may be blasted to open a hole for inspection and sampling. Two or more holes will be core drilled at each site to provide a permanent record.

The location of the test borings should be determined by judgement rather than by any specific pattern. Because of the cost, the pit should be developed with as few borings as possible, but sufficient borings should be made to delineate an area of suitable material sufficient to meet the requirements. A minimum of five borings is recommended and the Geotechnical Investigation Engineer should approve the plan in advance.

A log of all drilling should be kept. This log should show the depth and type of material encountered and the drilling time involved for each type. The log of cores will be made by a geologist and cores removed should be sent to the Phoenix Geotechnical Office for storage and possible future inspection by contractors.

After the holes have been drilled or blasted, they should be sampled in accordance with Section 106.00.

After sampling, each hole should be identified with the Metal tape, inspected, and backfilled as previously described in Section 104.02, or fenced.

C. Designation of Quarry Source

Quarry pits should be designated as aggregate sources as described in Section 104.03.

104.05 CUT WIDENING FOR BORROW AND AGGREGATE

In the absence of available borrow and/or aggregate, the possibility of widening the roadway cuts should be investigated. This decision should be made in cooperation with Plans Services and the Right-of-Way Section. If a decision is made to consider using the cuts for additional borrow or aggregate, then the roadway cuts should be controlled by the grade lines established by Plans Services.

104.06 PIT SKETCHES AND PHOTOGRAPHY

A field sketch shall be made of the pit area to a scale of from 200 feet to 600 feet to the inch, depending on the size and detail of the pit. The sketch should show the pit location with ties to the roadway alignment and also section ties where possible (see Figures 104.06-1 and 104.06-2). This sketch, or a

FIGURE 104.06-1

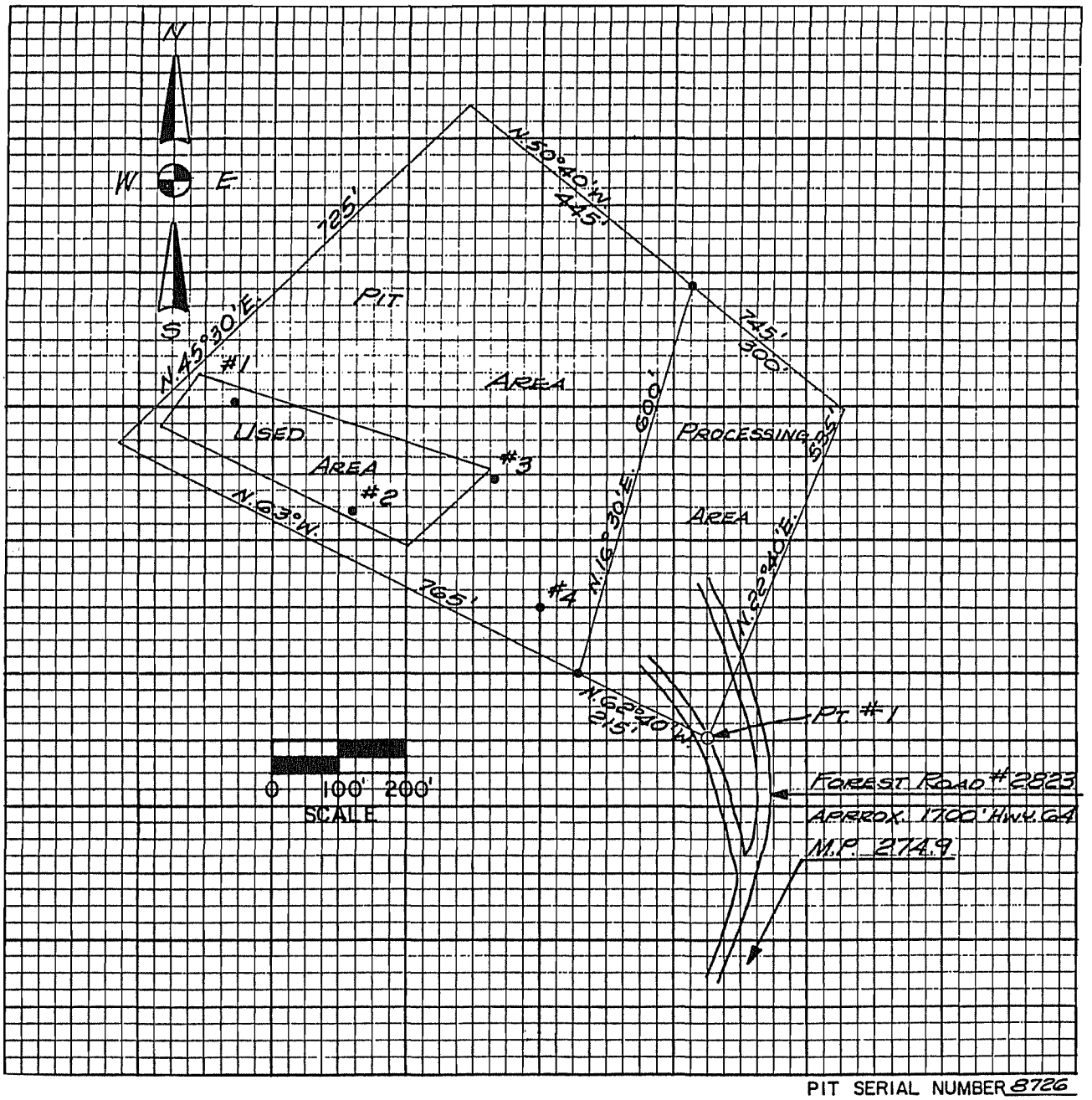
ARIZONA DEPARTMENT OF TRANSPORTATION
MATERIALS SECTION

FIELD REPORT ON LOCATION OF AGGREGATE PIT SERIAL NUMBER 8726

FROM GRAND CANYON - CAMERON HIGHWAY SOURCE OF MATERIAL FLAT

PROJECT NUMBER F-033-1-406 PROSPECTED BY RON MUENKS

A.F.E. DATE 2/10/88 LOCATION OF PIT SITE SECS. 3 & 4, T.29N., R.6E.



PIT SERIAL NUMBER 8726

FIGURE 104.06-2

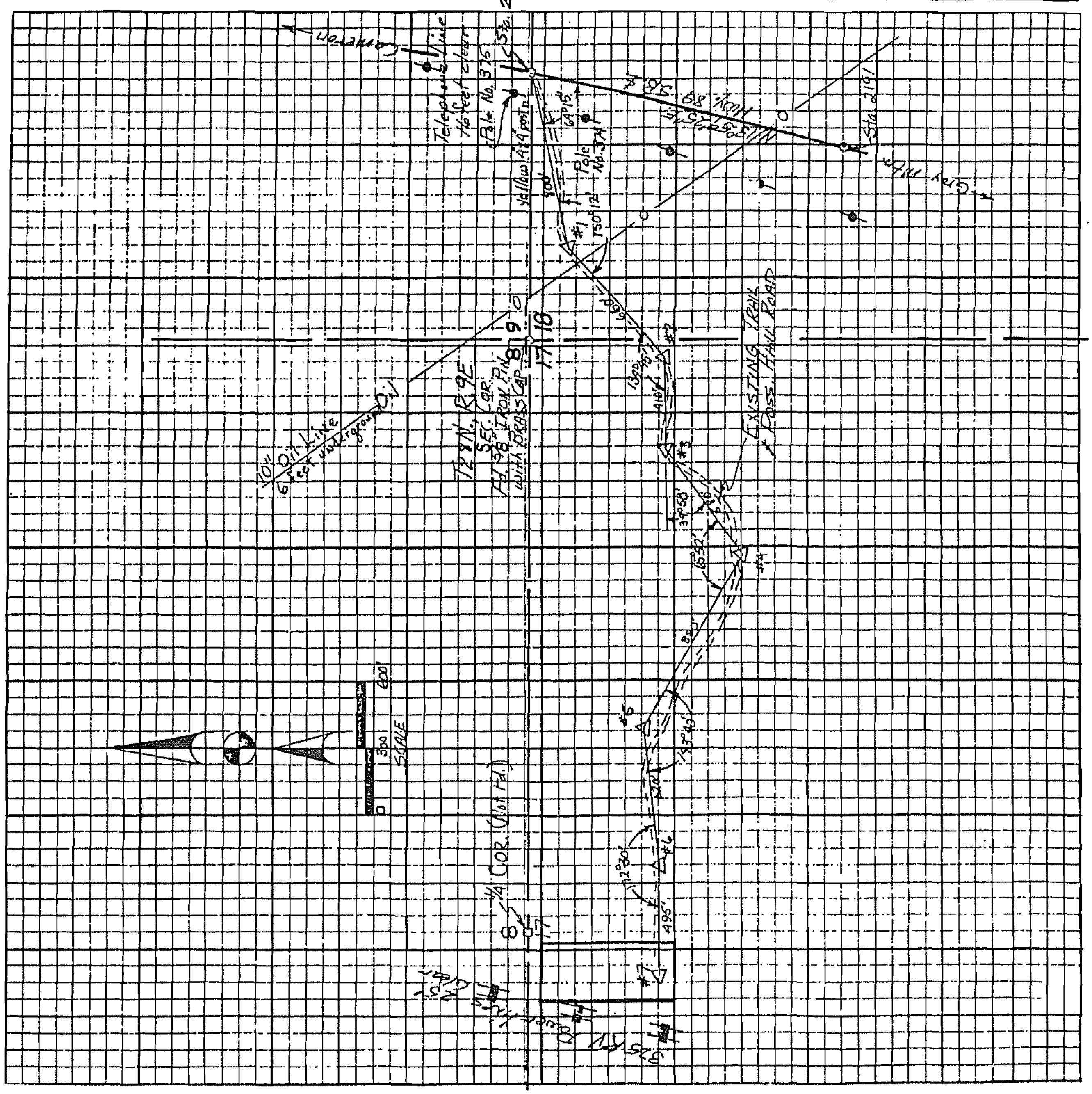
ARIZONA DEPARTMENT OF TRANSPORTATION
MATERIALS SECTION

FIELD REPORT ON LOCATION OF *Borrow* PIT SERIAL NUMBER *8390*

FROM *Gray Mtn. - Cameron* HIGHWAY SOURCE OF MATERIAL *Flat*

PROJECT NUMBER *F037-1-407* PROSPECTED BY *Best*

A.F.E. ______ DATE *2-10-88* LOCATION OF PIT SITE *4000' Lt. Sta. 2205*



supplemental sketch, shall show the most feasible haul route from the pit to the project. Both sketches should include such physical features (powerline, water line, fences, roads, pit excavations, etc.) that would help to identify the location and/or affect the contractor's operations at the source.

After the test holes have been dug and sketched, targets must be placed at specific identified points to aid in determining the scale and location of certain points and objects on the aerial photographs that will be taken of the haul road and pit area (see Figure 104.06-3).

Two points, approximately 500 feet apart and at approximately the same elevation, shall be marked by white plastic panels 18 inches wide with each leg being 10 feet long and forming a cross pattern. The distance between the centers of these targets shall be measured, by chain, to the nearest 0.01 foot, and shown on the sketch. Targets shall also be placed on the survey centerline station that the pit is located from and on the station the haul road is tied to. Where the centerline is on an existing road or highway, these targets should be placed on the side of the roadway opposite the station. If the existing road is asphalt surfaced, a small white cross can be painted on the pavement.

Targets shall also be placed on the closest section corner 1/4, or 1/16 corner available in the vicinity of the pit. The target on all section markers shall be placed forming a "Y" with three white plastic strips 18 inches wide and 10 feet long with the marker at the center.

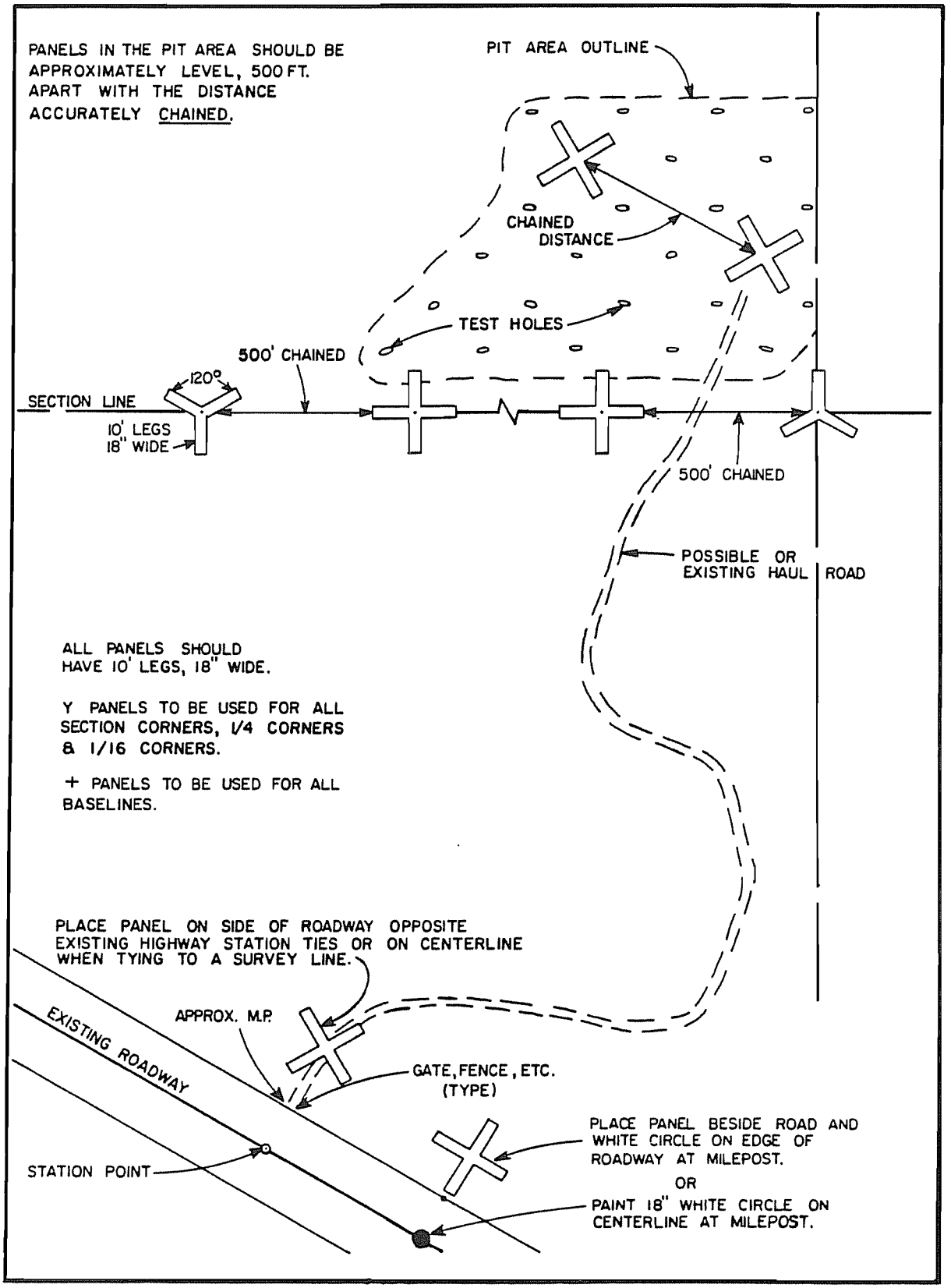
The location of all targets shall be accurately shown on the pit and/or haul road sketch.

Targets shall be placed on all pits at the completion of the materials investigation.

When all the pit sketches are received in the Phoenix Geotechnical Office, the Drafting Supervisor shall furnish Photogrammetry and Mapping Services with a flight plan for these pits on existing photography or maps, showing the pit location with the desired flight line and scale.

Normally a scale of one inch to 500 feet is adequate for the preparation of final pit sketches. In some instances, a scale of up to 1 inch to 2000 feet will be requested if more area is to be photographed, or a smaller scale may be requested if more detail is required.

FIGURE 104.06-3



When the photographs are received in the drafting area, the field sketches, with the aid of the targets placed on the ground, will be redrawn on the photographs (see Figures 104.06-4, 104.06-5 and 104.06-6).

In some cases, owners may require a development plan before granting right-of-way. In other cases, a plan of pit operation should be developed with pertinent drawings showing the proposed method and manner of removal of material. This plan should be mutually acceptable to all parties involved.

105.00 FIELD REVIEW

The Crew Supervisor responsible for the preliminary engineering soil investigation of a project should notify his supervisor immediately prior to completion so that a schedule can be set up for a field review. The Geotechnical Investigation Engineer, will review and approve the work or direct additional work to be performed. All field recommendations shall be reviewed and finalized.

The Geotechnical Investigation Engineer shall verify compliance to approved procedures on all phases of materials investigation. He shall in addition make observations as to the types, quality, and quantity of materials involved and make such observations to form a preliminary evaluation of design features and construction problems involved. Complete records must be made of all observations. The "R"-value locations both on the centerline and within the borrow pits shall be reviewed and approved or additional samples requested.

Complete acceptance of the field survey data must be obtained before the field materials investigation is considered complete. This may, in some cases, result in several visits to the project site.

After the field review has been completed and approved, the field party is to backfill or fence test holes. Backfilling or fencing should be accomplished as soon as possible.

105.01 WATER SUPPLY AND DUST CONTROL

The party responsible for the preliminary engineering subsurface investigation of a project should also ascertain the closest practical source of water for construction and dust control requirements.

FIGURE 104.06-4

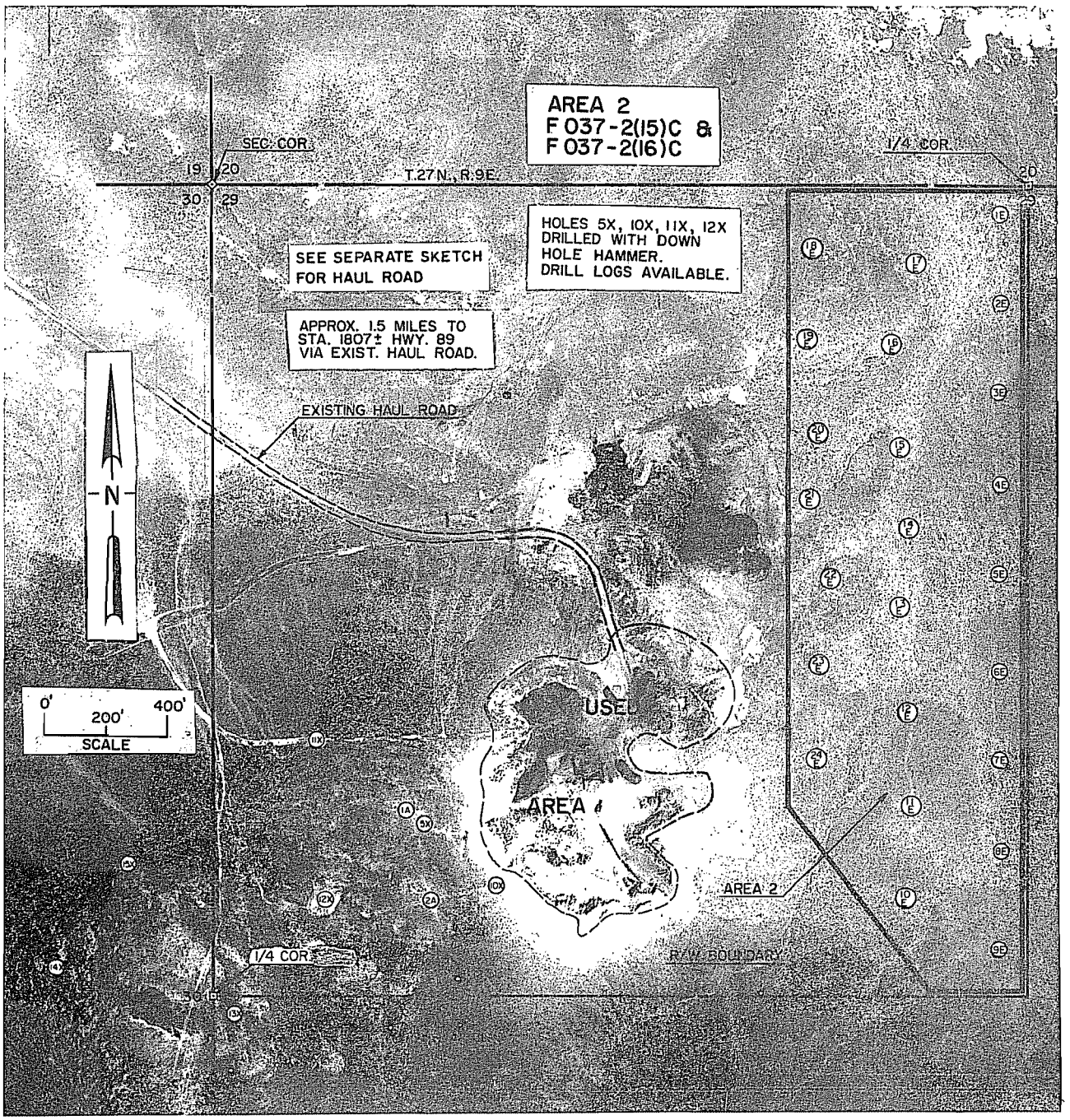
ARIZONA DEPARTMENT OF TRANSPORTATION
MATERIALS SECTION

FIELD REPORT ON LOCATION OF BORROW & AGGREGATE PIT SERIAL NUMBER 8491

FROM GRAY MOUNTAIN - CAMERON HIGHWAY SOURCE OF MATERIAL RIDGE & FLAT

PHOTO DATE 5-18-84 LOCATION OF PIT SITE NW1/4 SEC. 29 T.27N., R.9E.

PROSPECTED BY MUENKS DATE 3-1-84 SKETCH DATE 6-6-84



ARIZONA DEPARTMENT OF TRANSPORTATION
MATERIALS SECTION

FIELD REPORT ON LOCATION OF HAUL ROAD PIT SERIAL NUMBER 8491

FROM FLAGSTAFF - CAMERON HIGHWAY PHOTO DATE 5-18-84 SKETCH DATE 10-12-84

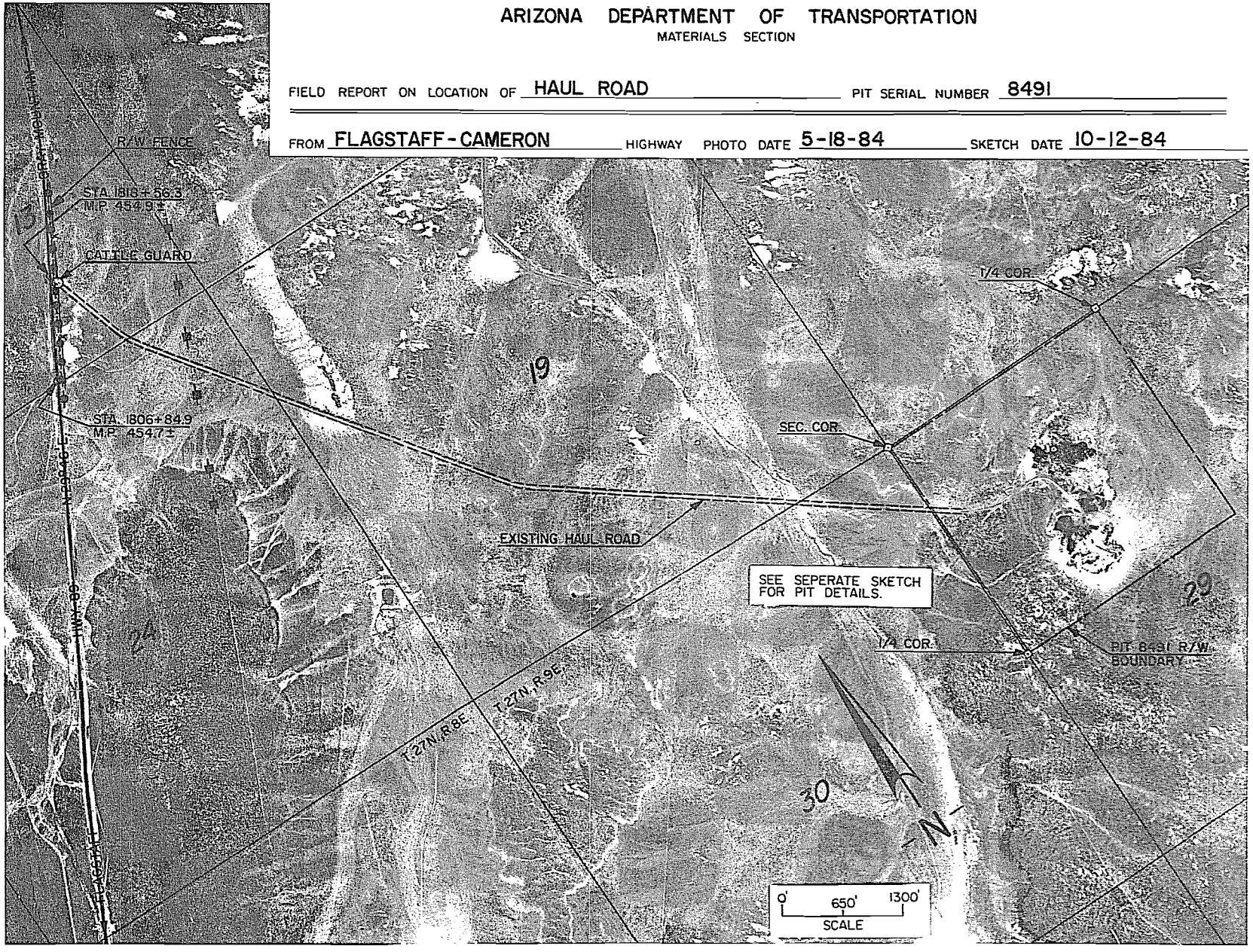


FIGURE 104.06-5

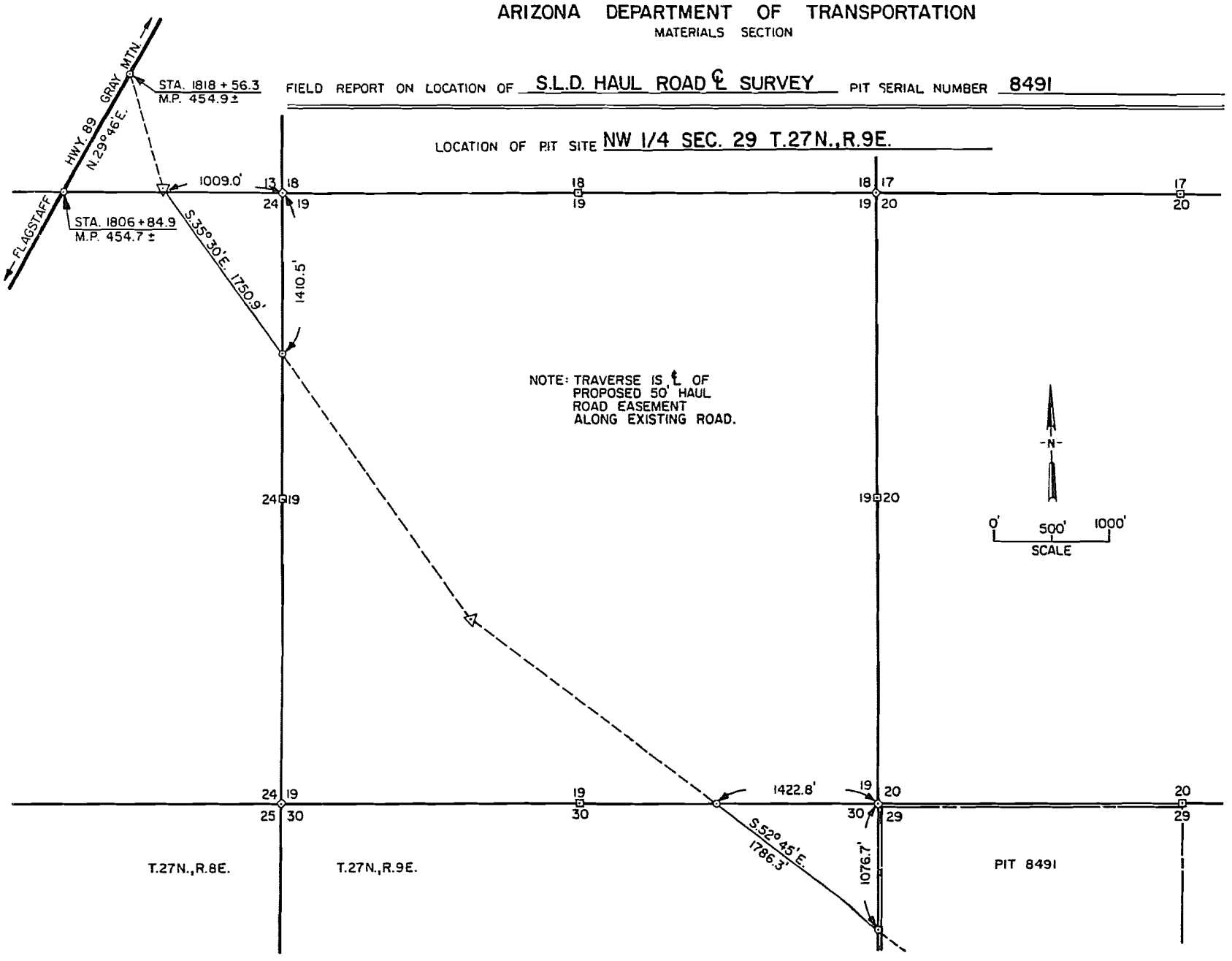


FIGURE 104.06-6

At the time of the field review, this proposed source of water will be reviewed and accepted or rejected on practical and economic merit. Factors which should be considered are:

A. Haul distance.

B. Quantity available (GPM...etc.)

C. Possible royalty charges.

D. Type of terrain project is located in; such as blow sand, clay, rock, etc.

E. Quantity required.

105.02 WASTE AREAS

On projects where the nature of the terrain will necessitate considerable waste of in-place materials, the Crew Supervisor and Geotechnical Investigation Engineer shall designate areas where a waste material may be deposited and determine their probable capacity. These recommendations are based on estimated waste quantities and may need revision during actual construction if the quantity is significantly different. Prior approval will sometimes be required due to environmental considerations.

An attempt should be made to utilize waste material where practicable. Flatter fill slopes (right-of-way permitting), rest areas, and emergency pull-outs are examples of utilization of waste materials.

When material pits contain overburden material that must be wasted, the material should be placed to avoid contamination of unused areas of the pit that may be needed for future projects. At times this material can be utilized as borrow or as a dike to protect the pit during use. Waste material should be placed so future flow in drainage channels is not modified.

106.00 SAMPLING TECHNIQUES

The securing of a relatively small sample to represent a large quantity of material is one of the most important functions in the materials design process. This may only be accomplished by: 1) careful consideration of all material types that are exposed in a test hole or on a pit face; 2) the ability of the sampler to make the proper value judgement in selecting the point of sampling; 3) then "cutting" a representative

sample. Since this is the absolute beginning of the physical handling of materials, it is extremely important to secure a sample that represents the proposed material source or subgrade.

In all cases, applicable safety regulations shall be followed.

In the sections that follow, four different sampling techniques to fit four different situations will be discussed.

106.01 SAMPLING ALLUVIAL MATERIALS

Alluvial materials are sand, gravel, soil, silt, clay or similar materials that have been deposited by water.

The ability to take a representative sample of alluvial material comes after one has acquired the knowledge to distinguish between the different strata exposed by a test hole and to select the area of the test hole that will constitute the best representation of the exposed material. The sample is then secured from the selected area on the vertical face of the test hole.

A. Tools and Equipment

1. Prospector's Pick
2. Sampling Canvas
3. Four-foot Straight Edge
4. Sugar Scoop
5. Two-inch Paint Brush
6. Supply of Sample Bags
7. Twelve-foot Steel Tape
8. Ladder

B. Sampling Procedure

Immediately after the test hole has been excavated and is determined to be safe for entry, the following procedure shall be followed:

1. Lower the ladder into the test hole and enter the test hole.

2. Survey the exposed material and select the sampling point.

3. Place the sampling canvas in the bottom of the test hole.

4. Use the prospector's pick to cut a trench along the vertical face for the entire thickness of the stratum (layer) to be sampled. The width and depth of the trench shall be uniform. Care should be taken that all material from the trench falls on the canvas and care should also be taken that materials from other areas of the hole do not fall onto the canvas. A sufficient amount of material shall be cut to allow the mixing and quartering of the sample with one-quarter of the sampled material filling a sample bag. (An "R"-value sample generally will not require quartering.)

5. Immediately remove the material from the test hole, measure the thickness of the stratum that was sampled and record this information along with a description of the material on the sample log sheet (Figure 106.01-1a or 106.01-1b).

6. From the data on the sample log sheet, prepare the sample ticket (Figure 106.01-2a) that is to be tied to the sample bag (see Section 106.05). Figure 106.01-2b is the matrials survey soil and aggregate tabulation laboratory card. The back of this card, Figure 106.01-2c, contains codes to be used in filling out the sample ticket. For convenience the material codes and roadway codes are also shown on the back of the sample ticket.

7. The material shall then be thoroughly mixed and quartered with a straightedge if necessary.

8. All but one quarter of the material shall be removed from the canvas. The remaining material shall be placed into the sample bag with the scoop.

9. The paint brush shall be used to brush all remaining fines clinging to the sample canvas into the scoop and this material shall be placed into the sample bag.

10. The sample bag shall be tied and the sample ticket affixed to the tying string (see Section 106.05).

11. Each stratum shall be sampled in the same manner.

ARIZONA DEPARTMENT OF TRANSPORTATION – MATERIALS SECTION

PRELIMINARY ENGINEERING SUBGRADE LOG

(USE CAPITAL LETTERS ONLY)

PROJECT NUMBER S 482-408 PROJECT LOCATION Colter Road SAMPLED BY Smith

PROJECT TERMINI Sta. 420+00 to 732 DESIGNER Jones CONSTRUCTION TYPE New Rdwy.

SAMPLE NUMBER	DISTANCE	R OR L	RDWY.	MILEPOST OR STATION	DEPTH FROM	DEPTH TO	INVEST. MODE	MATL. DESC. #1	MATL. DESC. #2	DATE YEAR 84 MO.	DATE DAY	MATERIAL DESCRIPTION	TESTS REQUIRED OTHER THAN GRADATION & PI
15	12.5	R	E.B.	603+45	0'	3'	01	31		10	8	Clayey Silt, Damp, Tan	R-Value

FIGURE 106.01-1a

ARIZONA DEPARTMENT OF TRANSPORTATION – MATERIALS SECTION
PRELIMINARY ENGINEERING MATERIALS PIT LOG
(USE CAPITAL LETTERS ONLY)

PROJECT NUMBER I-10-3(306) PROJECT LOCATION Jacks T.I. - East PIT NUMBER 9002

PIT LOCATION 1800' Lt. Sta. 425+50(W.B.) SAMPLED BY Smith MATERIAL Aggregate

TEST HOLE NO.	SUFFIX	DEPTH FROM	DEPTH TO	INVEST MODE	MATL. DESC. #1	MATL. DESC. #2	DATE YEAR 84 MO.	DATE DAY	MATERIAL DESCRIPTION	TESTS REQUIRED OTHER THAN GRADATION & PI
8		0'	12'	01	23		10	3	Sand & Gravel, Thin Silt layer @ 6'	pH & Resist.
		12'	12'	01	23		10	3	Water	N.S.

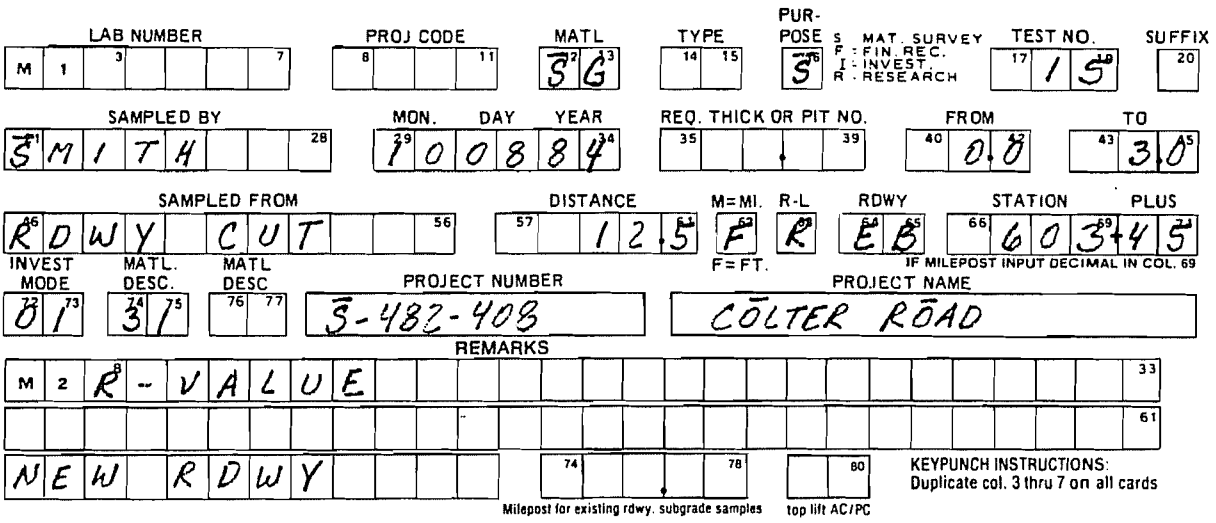
PIT NUMBER 9002

FIGURE 106.01-1b

FIGURE 106.01-2a

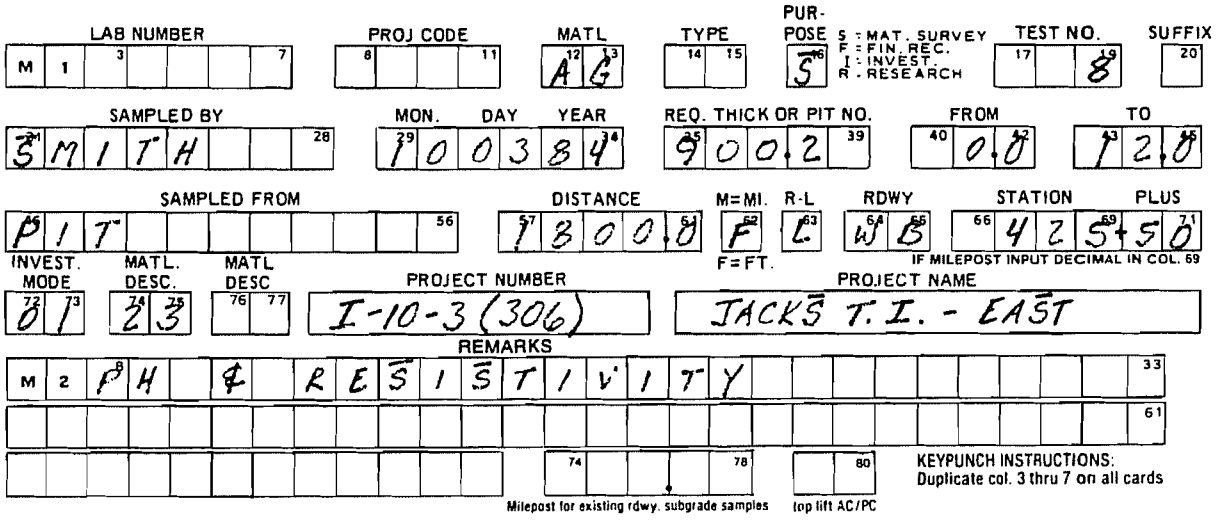
44-9349 R4/89

SAMPLE TABULATION FOR MATERIALS SURVEY



44-9349 R4/89

SAMPLE TABULATION FOR MATERIALS SURVEY



MATERIAL CODES

SG = SUBGRADE
SB = STRUCTURE BACKFILL
AS = AGGREGATE SUBBASE
SS = SUBGRADE SEAL
NG = NATURAL GROUND
BM = BEDDING MATERIAL
AB = AGGREGATE BASE
CM = COVER MATERIAL
BL = BLOTTER MATERIAL
MA = MINERAL AGGREGATE
CA = COARSE AGGREGATE
FA = FINE AGGREGATE
AG = AGGREGATE
EM = EMBANKMENT.
CB = CEMENT TREATED BASE
LC = LEAN CONCRETE BASE
CS = CEMENT TREATED SUBGRADE
LS = LIME TREATED SUBGRADE
RR = RIP RAP
FM = FILTER MATERIAL
BO = BORROW
GR = GRANULATED RUBBER
TS = TOP SOIL
BF = BACKFILL
AC = ASPHALTIC CONCRETE
BB = BITUMINOUS TREATED BASE
FC = ACFC
NM = PNEUMATICALLY PLACED MORTAR
MS = MEMBRANE SEAL
RM = ROAD MIX
RC = RECYCLED ASPHALTIC CONCRETE

RDWY CODES:

NB = NORTHBOUND
SB = SOUTHBOUND
ETC
RA = RAMP A
RB = RAMP B
ETC
FR = FRONTAGE ROAD
XR = CROSS ROAD

FIGURE 106.01-2b

MATERIALS SECTION
SOIL & AGGREGATE TABULATION
MATERIALS SURVEY

RECEIVED DATE _____

LAB NUMBER	PROJ CODE	MATL	TYPE	PURPOSE (S: MAT SURVEY, F: FIN REC, I: INVEST, R: RESEARCH)	TEST NO	SUFFIX
M 1		SG		S	15	

SAMPLED BY	MON.	DAY	YEAR	REQ. THICK OR PIT NO.	FROM	TO
SMITH	10	08	84		0.0	3.0

SAMPLED FROM	DISTANCE	M=MI. F=FT	R-L	RDWY	STATION	PLUS
RDWY CUT	125	F	R	EB	603	45

IF MILEPOST INPUT DECIMAL IN COL. 69

INVEST MODE	MATL. DESC.	MATL DESC	PROJECT NUMBER	PROJECT NAME
01	31		S-482-408	COLTER ROAD

REMARKS

M 2 R-VALUE

NEW RDWY.

KEYPUNCH INSTRUCTIONS: Duplicate col. 3 thru 7 on all cards

M 3 — % OVERSIZE: +3" ☐ (8 9) +6" ☐ (11) — COARSE FACTOR

	WEIGHTS RETAINED	% RET.	% PASS (no punch)
3" ☐	12–16		
2½"	21		
2"	26		
1½"	31		
1"	36		
3/4"	41		
1/2"	46		
3/8"	51		
1/4"	56		
#4	61		
-#4	66		
Total	71		

Liquid Limit, (LL) T-87 D-421	38	40
Plastic Limit (PL) T-89 D-423		42
Plasticity Index (PI) = LL − PL T-90 D-424		44
Sand Equivalent, SE = S/C × 100 T-176 D-2419		46
Abrasion (A,B,C,D) T-96 C-131		47
@ 100 Revolutions		49 %
@ 500 Revolutions		51 %
Absorption, H_2O ARIZ-211, T-85 C-128		55 %
Specific Gravity, OD " "		59
Density Method (A,C,D,1)		60
Optimum Moisture		63 %
Max. Dry Density		67 PCF
Moisture Content = (W-D)/D × 100 T-255 C-566		70
pH		73
Resistivity (ohm-cm)		78
R-Value @ 300 psi		80

T = AASHTO Tests
C & D = ASTM Tests

MISCELLANEOUS TEST CODES
01 Soluble Salts
02 Organic Impurities
03 Sodium Sulphate Soundness
04 Swell
05 Shear
06 Consolidation
07 % Limestone
08 % Cement
09 % Lime
10 % Flyash
11 Unit (loose) Weight
12 Stripping Test (accelerated)
13 Permeability
14 Freeze-Thaw
15 CBR
16 Flakiness Index
17 Fractured Faces
18
19
20

M 4 — WT PASS #4 SPLIT (8 10) — FINE SIEVE FACTOR

	WEIGHTS RETAINED	% RET. (no punch)	% PASS
#8	11–13		
#10	16		
#16	19		
#30	22		
#40	25		
#50	28		
#100	31		
#200	34		
-#200	37		
Total	Dry Weight		
Elutriation			

M 5 — MISCELLANEOUS TESTS

Hydrometer (Smaller than) .020 mm	8	10 %
(Smaller than) .002 mm		13 %
(Smaller than) .001 mm		16 %
Mortar Strength		19 %
20 Test Code 22		27
28 Test Code 30		35
36 Test Code 38		43
44 Test Code 46		51
52 Test Code 54		59

NOTE:
Input decimal point as needed for results on miscellaneous tests

† 44-9351 R3/86

FIGURE 106.01-2c

MATERIALS SURVEY CODES

INVESTIGATIVE MODE CODES	MATERIAL DESCRIPTION CODES
01 Backhoe	01 Basalt (Malpais)
02 D&S - Backhoe	02 Cinders
03 D&S - Backhoe - Fines wasted	03 Andesite or rhyolite
04 Backhoe - Fines wasted	04 Tuff or compacted ash
05 Face Sample - Backhoe	05 Diabase
06 Backhoe - Crushed	06 Granite
07 D&S - Backhoe - Crushed	07 Disintegrated (Decomposed) Granite
08 D&S - Backhoe - Fines wasted - Crushed	08 Slate
09 Backhoe - Fines wasted - Crushed	09 Schist
10 Face Sample - Backhoe - Crushed	10 Quartzite
	11 Shale
21 Hand shovel	12 Siltstone
22 D&S - Hand shovel	13 Sandstone
23 D&S - Hand shovel - Fines wasted	14 Conglomerate
24 Hand shovel - Fines wasted	15 Limestone
25 Face Sample - Hand shovel	16 Chert (Flint)
26 Hand shovel - Crushed	17 Caliche
27 D&S - Hand shovel - Crushed	18
28 D&S - Hand shovel - Fines wasted - Crushed	19
29 Hand shovel - Fines wasted - Crushed	20 Sand and gravel, with cobbles or boulders.
30 Face Sample - Hand shovel - Crushed	21 Silty-Sand and gravel, with cobbles or boulders.
	22 Clayey-Sand and gravel, with cobbles or boulders.
35 2" Drill hole	23 Sand and gravel
	24 Silty-Sand and gravel
41 4" Auger	25 Clayey-Sand and gravel
42 4" Auger - Fines wasted	26 Sand
43 4" Auger - Crushed	27 Silty-Sand
44 4" Auger - Fines wasted - Crushed	28 Clayey-Sand
	29 Sandy Silt
50 4½" Drill hole	30 Silt
	31 Clayey Silt
55 6" Auger	32 Clay or silty-clay, gravelly
56 6" Auger - Fines wasted	33 Clay or silty-clay, sandy
57 6" Auger - Crushed	34 Clay or silty-clay
58 6" Auger - Fines wasted - Crushed	35 Clay
60 8" Auger	
61 8" Auger - Fines wasted	
62 8" Auger - Crushed	
63 8" Auger - Fines wasted - Crushed	
70 2' Sq. Jackhammer Sample	
71 4" Core	
72 6" Core	
73 8" Core	
74 12" Core	

MATERIAL CODES

SG = SUBGRADE
SB = STRUCTURE BACKFILL
AS = AGGREGATE SUBBASE
SS = SUBGRADE SEAL
NG = NATURAL GROUND
BM = BEDDING MATERIAL
AB = AGGREGATE BASE
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TS = TOP SOIL

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LS = LIME TREATED SUBGRADE
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FM = FILTER MATERIAL
GR = GRANULATED RUBBER

BF = BACKFILL
AC = ASPHALTIC CONCRETE
BB = BITUMINOUS TREATED BASE
BO = BORROW
FC = ACFC
NM = PNEUMATICALLY PLACED MORTAR
MS = MEMBRANE SEAL
RM = ROAD MIX
RC = RECYCLED ASPHALTIC CONCRETE

RDWY CODES:

NB = NORTHBOUND
SB = SOUTHBOUND
ETC
RA = RAMP A
RB = RAMP B
ETC
FR = FRONTAGE ROAD
XR = CROSS ROAD

106.02 SAMPLING QUARRY PITS

The sampling of a quarry pit requires the use of judgement as well as routine technique. The purpose of the sample is to provide material that may be processed to produce an end product as close as possible to what would be expected during construction.

The test hole should be chosen carefully to note any change in material. This change is usually evident in the color and the degree of hardness. If there is more than one type of material in the test hole, each type should be represented by a sample of approximately 60 pounds. The sample should be taken from the material excavated from the hole.

The test hole should be hand picked with care being exercised to select material representing only the stratum being sampled. The sample should include only rock that will pass a 6 inch sieve. The material should be placed in bags and tagged showing the location and extent of the stratum it represents. The words "Quarry Crush" should appear on all identifying tags.

At least two samples from each of the usable strata should be marked "For Abrasion", with a minimum of three samples for the entire pit.

An additional sample shall be taken from every second or third test hole for information only. These samples should consist of the fine material generated from the blasting operation, together with approximately an equal amount of the fine material extracted from the fracture seams and bedding planes exposed in the test hole. These samples shall be marked "FINES - FOR INFORMATION ONLY". The number of the test hole the sample was taken from also should be shown on the card.

106.03 SAMPLING EXISTING ROADWAYS

Care should be exercised in sampling existing roadways in order to accurately represent the thickness and characteristics of each pavement component and the subgrade.

A. Existing Pavement

The existing pavement should be cut to a neat line for an area approximately two feet by two feet. The pavement should be carefully removed to the elevation of the next component. Generally, the material may later be used for backfilling the hole or discarded, unless a sample has been requested. If a sample has been requested, then the pavement material should be

placed in a sample sack, tied, and tagged as described in Section 106.05. Samples are logged on the form shown in Figure 106.01-1a. A core drill can often be utilized to obtain existing pavement samples when such equipment is available. The sampling method will be determined by the Geotechnical Investigation Engineer.

B. Base Course Components

Each of the base course components should be removed separately. The material may be removed by hand, using a scoop or a spoon. Care should be taken to remove all of the material of the particular components, using the hands or the spoon and brush to clean up the fines. All of the material removed should be placed on the sample cloth. If there is not more than one bag full, all of the material should be placed in a sample bag. If there is more material than is required for a sample, the material should be thoroughly mixed and divided with the straight edge until there is approximately enough material in a sample portion to fill one bag. It should then be bagged, tied, and tagged as described in Section 106.05. Samples are logged on the form shown in Figure 106.01-1a.

C. Subgrade

After the pavement and each base component have been removed, excavation should continue at least six inches into the subgrade with the material sampled in the same manner as the base course components. For reconstruction projects, "R"-value samples in addition to normal samples, will be taken from these subgrade materials which the supervisor determines to be control conditions. The R-value samples shall be taken beneath the pavement; sampling from the shoulder will not be permitted.

The R-value sampling requirements for reconstruction projects are the same as in Section 102.04 with a minimum of 3 per project. On investigation for rehabilitation projects, no R-value samples need be taken unless there has been a specific request for them.

D. Backfill

After each component of the pavement structure has been sampled the hole should be backfilled, using the surplus material and other suitable material. It should be hand tamped and the top six inches should be replaced with asphaltic mix. The District in which the work is to be done should be notified of the location of the holes in case they choose to do the backfilling with the District Maintenance Forces. In no case, however, should a hole be left in the pavement when opened to traffic.

106.04 SAMPLING OVERSIZE AGGREGATE

The percentage of material retained on the 3 inch and 6 inch sieves in aggregate pits is important from several standpoints. It indicates the amount of crushing required and it influences the job mix formula in asphaltic concrete mix designs. For these reasons, it is important to make a concerted effort to determine as closely as possible the amount of oversize rock that is indicated by the test holes. There are several steps involved: selection of holes to be sampled, taking the sample, weighing the sample and calculating the percentage of each size.

A. Selection of Holes to be Sampled

After all test holes have been excavated, a study should be made of each hole from the standpoint of oversize rock; then three or more representative holes should be chosen to represent the pit or pit area. It is desirable to select holes that cover the entire pit area; if one area of the pit appears to contain a significantly different amount of oversize, a separate determination for the individual areas may be more appropriate.

B. Sampling

Because of the influence of one large rock, it is essential that a fairly large sample should be taken, particularly if the percentage of oversize is great. Hence, a minimum of 1000 pounds of material should be removed from the test hole. This may be accomplished by cleaning out the bottom of the hole with the backhoe and removing as much of the loose material as possible, then with the backhoe bucket, as carefully as possible, remove material from the face of the test hole. The operation should begin at the bottom, taking a shallow cut towards the top, trying to get a uniform sample.

C. Weighing

All material removed as a sample should be weighed. Since it is not practicable to have a large scale on the project, it should be weighed in increments that can be easily lifted and handled, with a hand scale. As each increment is weighed, the weight should be tabulated and the tabulations totaled to determine the entire weight of the sample. This weight should be entered for each test hole sampled (see Figure 106.04-1).

As each increment of material is removed from the container in which it was weighed, it should be dumped on a 3 inch sieve. All material retained on the 3 inch sieve should be saved and after the entire sample has been weighed, the material retained

FIGURE 106.04-1

ARIZONA DEPARTMENT OF TRANSPORTATION
MATERIALS SECTION

FIELD REPORT ON LOCATION OF AGGREGATE PIT SERIAL NUMBER 8686

FROM LAKESIDE STREETS HIGHWAY SOURCE OF MATERIAL WASH

PROJECT NUMBER E044-1-301 PROSPECTED BY RON MUENKS

A.F.E. DATE 2/10/88 LOCATION OF PIT SITE 16 Mi. Lt. MP 322.1 Hwy. 26

FIELD SCREEN ANALYSIS

HOLE NUMBER	TOTAL WEIGHT	WT. RET. ON 6" SCREEN (1)	WT. RET. ON 3" SCREEN (2)	SIEVE ANALYSIS			
				% RET. 6" (3)	% RET. 3" (4)	% PASS 6" (5)	% PASS 3" (6)
#6	1378	45	219	3.27	15.89	96.73	80.84
#16	1570	100	150	6.37	9.55	93.63	84.08
#19	1547	50	245	3.23	15.84	96.77	80.93
#37	1622	50	289	3.08	17.82	96.92	79.10
#40	1574	45	176	2.86	11.18	97.14	85.96
#46	1900	75	318	3.95	16.74	96.05	79.31

(1) Only the material that will not pass a 6" screen.

(2) Only the material that will not pass a 3" screen, exclusive of that material retained on the 6" screen.

(3) Weight of material retained on the 6" screen divided by the total weight.

(4) Weight of material retained on the 3" screen divided by the total weight.

(5) 100% Minus percent retained on the 6" screen.

(6) Percent passing the 6" screen minus the percent retained on the 3" screen.

on the 3 inch sieve should be passed over a 6 inch sieve and separated. The portion retained on the 6 inch sieve should be weighed and the weight entered in column (1). The balance of the oversize (retained on 3") should be weighed and the weight entered on the form in column (2). All weights entered should be to the nearest pound. Boulders larger than approximately 15 inches should not be included in the sample.

D. Calculating the Percentage of Each Size

After all weights are entered, the percentage retained on each sieve and the percentage passing each sieve should be calculated to the nearest tenth of a percent according to instructions on the form and the percentage for each sieve entered in the appropriate column (see Figure 106.04-1).

106.05 IDENTIFYING SAMPLES

All samples should be identified by filling out the sample ticket (see Figure 106.01-2a). This ticket is a multiple copy form. The original should be removed and placed in the sample bag. The second copy should be attached to material log. The third copy should be attached to the outside of the bag to serve as a shipping tag. The ticket should be carefully filled out to provide the necessary information.

A. Name of Material:

The name of the material being sampled should be entered in the appropriate place. This would usually be one of the following: Subgrade, Borrow, Special Backfill, Aggregate or Oversize. There may be other materials sampled on occasion, such as Riprap Rock, Blending Material, etc. The "R"-value samples shall be identified on the sample ticket under REMARKS.

B. Identification Marks:

Because there is usually more than one sample, each sample should be identified by number. These numbers should correspond with the test hole. The sample taken in each stratum is given the number of the test hole and further identified by the location of the stratum. For example, #14 - 2′ to 9′, #14 - 9′ to 12′.

C. Date:

The date the sample is taken should be entered on the identification ticket in the place indicated.

D. Sampled By:

The name of the party responsible for the sampling should be entered on the identification ticket in the place indicated. If the sample is taken by a Field Crew, the name of the Crew Supervisor should be used. If the sampling is under the direction of a Geotechnical Investigation Engineer or District personnel, the name of the person supervising the sampling should be used.

E. Sampled From:

The point from which the sample is actually taken should be entered on the identification ticket in the place indicated. This may include a test hole in the subgrade or pit, it may be from a stockpile, from the bins of a plant, or a railroad car, and should be so indicated. If the sample is taken from a test hole or windrow in the roadway, the station should be indicated.

F. Quantity Represented:

The quantity represented should be entered on the identification ticket in the place indicated. If the sample is taken from a test hole it should indicate the location and thickness of the stratum sampled; for example, 0′ to 11′.

If the sample is taken from a stockpile, it should indicate the estimated amount of material in the stockpile. If it is taken from an operating plant, it should indicate the amount of production represented.

G. Location of Supply:

The specific location of the source of the supply of material sampled should be entered on the identification ticket in the appropriate place. If the source is an Arizona Department of Transportation pit, the serial number of the pit should be given if one has been assigned, or, if it is a new pit and no number has been assigned, the location of the pit as it will appear on the pit sketch should be used. If it is the roadway, it should be so indicated. If it is a commercial plant it should be so stated with the location of the plant indicated and its number, if one has been assigned. For example: Commercial Plant, United Metro #1, (CM 0059), Phoenix.

H. Highway:

When the location of the supply is related to a Station or Milepost, the name of the appropriate highway on which the

Station or Milepost is located should be entered in the place indicated.

I. Project Number:

The number of the project for which the material is being sampled should be indicated in the appropriate place.

J. Remarks:

Any pertinent information may be included under the remarks, such as the type of test for which the material was sampled, any special instructions for handling the sample or the name of an individual to be contacted regarding the sample.

106.06 SIZE AND NUMBER OF SAMPLES

The size of the sample required is determined by the number and type of tests that are to be made. In general, one sample should be taken from each stratum of material in each test hole for Sieve Analysis and Plasticity Index (PI) tests, together with other samples for specific tests as required. The size of samples and number of samples to be taken are shown in Table 106.06-1.

107.00 COMPLETION OF SAMPLING OPERATIONS

Prior to moving the equipment from the project site, all test holes should be filled or fenced, debris cleaned up and the work area restored.

Any test hole that is to be left open for future inspection should be fenced in accordance with details shown on Figure 107.00-1.

All papers, empty cans, bottles or debris of any kind developed in the materials investigation should be picked up and disposed of.

The work area should be restored as nearly as is practicable to its original condition. All piles of materials should be leveled and all excavations backfilled.

TABLE 106.06-1

S A M P L I N G S C H E D U L E

A. Subgrade and Borrow Pits

Type of Test	Number of Samples	Size of Each Sample
1. Sieve Analysis and P.I.	1 for each stratum of each test hole.	25 - 30 lbs.
2. Density	At least one at locations of in-place density test. Minimum of 3 for each pit.	75 - 100 lbs.
3. pH and Resistivity	1 for each CMP location on roadway Minimum of 3 for each pit.	25 - 30 lbs.
4. "R" Value	At least 1 for each "Control" point on centerline as directed by the Geotechnical Investigation Engineer and a minimum of 3 each in the borrow pits from controlling locations.	75 - 100 lbs.
5. Soluble Salts	Minimum of 3 for each borrow pit.	25 - 30 lbs.
6. Frost Susceptibility	Minimum of 3 for each soil type in a pit or subgrade (unless engineer gives other instructions).	25 - 30 lbs.

B. Aggregate Pits

1. Sieve Analysis and P.I.	1 for each stratum of each test hole.	25 - 30 lbs.
2. Density	Minimum of 3 for each pit.	75 - 100 lbs.
3. pH and Resistivity	Minimum of 3 for each pit.	25 - 30 lbs.
4. Abrasion	Minimum of 3 for each pit.	60 - 75 lbs.
5. Oversize	Minimum of 3 for each pit.	75 - 100 lbs.
6. % Limestone Determination	Minimum of 2	75 - 100 lbs. (1 large sack-including oversize)

FIGURE 107.00-1

FENCING OF OPEN TEST HOLES